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# Addressing the Workforce Pipeline Challenge

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**Abstract** – *A secure and affordable energy supply is essential for achieving U.S. national security, in continuing U.S. prosperity and in laying the foundations to enable future economic growth. To meet this goal the next generation energy workforce in the U.S., in particular those needed to support instrumentation, controls and advanced operations and maintenance, is a critical element. The workforce is aging and a new workforce pipeline, to support both current generation and new build has yet to be established. The paper reviews the challenges and some actions being taken to address this need.*

## I. INTRODUCTION

A secure energy supply is critical for enduring prosperity and central to delivery of energy is the skilled workforce needed to develop and maintain the technologies and infrastructure. The U.S. currently meets about 20% of its electricity demand using nuclear technology. The existing plants are remaining on line with both power up-rate and life extension programs. Consideration is also being given to opportunities for new build and more than 20 combined construction permits and operating licenses for new plants are reported to being considered within the community. As the U.S. looks to address energy supply there is the challenge of an aging energy workforce, and this is compounded by the apparent lack of skilled indigenous replacements.

The energy industry incorporates a broad range of sectors, including: petroleum and natural gas extraction, refining, and distribution; electric power generation, distribution and mining. Public utilities employed about 600,000 workers in 2002. Electric power generation, transmission, and distribution provided almost three in four utility jobs (436,000), while natural gas distribution (116,000) and other systems (48,000) provided the rest of the jobs (U.S Bureau of Labor Statistics). The Gross Domestic Product (GDP) for the energy industry, including electric and gas utilities, nuclear power generation, mining (including coal and minerals), and oil and gas extraction in 2003 was $352 billion, a 3.2% share of the national total. (U.S. Bureau of Economic Analysis) Much of the rest of the economy, and life style, is dependent on a secure and affordable energy supply. Ensuring electricity supply is essential for achieving U.S. national security, in continuing U.S. prosperity and in laying the foundations to enable future economic growth.

The workforce challenges that the U.S. faces over the next few decades are much wider than just meeting workforce needs in the energy sector. The failure to produce mathematicians, scientists and engineers in America is a tremendous threat to America's economic security. Dr. Shirley Jackson, the president of Rensselaer Polytechnic and president of the American Association for the Advancement of Science (AAAS) has been reported as saying that, “If we Americans don't do something soon and dramatic to reverse this "erosion,"*(in science and math education)* we are not going to have the scientific foundation to sustain our high standard of living in 15 or 20 years.”

In meeting utility workforce needs the instrumentation, controls (I&C), operations and maintenance communities are further challenged by the technology reformation that has occurred in the non-nuclear I&C community since the last commercial nuclear power plants were designed and built. There is the challenge of knowledge loss and lack of entry level staff looking to utilities, particularly nuclear plants, which are dependent on out-dated analogue systems. The current fleet is being challenged to maintain staff expertise for the aging analogue systems and to develop required new skills to support developing hybrid analogue-digital systems, and those digital systems that may be used in new build.

There is an advanced instrumentation community within the U.S., but it is supporting the wider information technology, manufacturing, petroleum and chemical industries, defense and aero-space communities. These other communities have, in many cases, already introduced advanced digital systems and modern control rooms, and are looking to integrate new strategies for system health monitoring.

The workforce challenge that needs to be addressed, associated with existing plants, involves knowledge retention of retiring employees, developing new educational organizations and government partnerships, talent management programs, increasing diversity, restructuring and optimizing organizations for greater efficiency, creating "pools of talent," and understanding workforce generation differences and why they matter.

As there is an increasing probability that new nuclear power plants will be built using advanced light water technology, and in the longer term other systems, a new workforce pipeline is needed. In creating this pipeline, clear paths to good, well paid and rewarding careers need to be publicized, which will attract both entry level and more mature workers.

## II. THE PEOPLE CHALLENGE

It is projected that 40% of the U.S. skilled workforce can retire within about four years. It is further reported that the energy industry faces higher levels of retirement than this. Within the U.S. Department of Energy (DOE) complex 75% of those workers with nuclear and related technology expertise could retire by 2010.[1] According to the 'Aging Workforce Report' recently conducted by UTC Research, the median age for workers in the utilities sector (including telecom) is 3.3 years higher than the national average, with nearly half of the utility workforce over the age of 45.[2]

The Department of Labor projects that jobs requiring science, engineering, and technical training will increase 51% from 1998 to 2008. This is 4 times faster than overall job growth and as a result some 6 million job openings will exist for scientists, engineers, and technicians. There will be competition for those with skills needed to ensure energy supply, and other industries are commonly seen as more attractive places to work.

A series of recent studies discuss the science and engineering labor force and in particular the nuclear education and staffing challenge that is facing the U.S.[1] and other nations. The National Science Board[3] with the report “Science and Engineering Indicators, 2004” and the companion document, “An emerging and critical Problem of the Science and Engineering Labor Force”;[4] “highlight trends that threaten the economic welfare and security of our country.” In the past two years the situation has not improved. The National Science Board[5] with the report “Science and Engineering Indicators, 2006” and the companion document, “America’s pressing challenge – building a stronger foundation ”;[6] “highlights systematic failures in education that are alarming.” A wider ranging compilation of insights is provided in the National Academies “Rising above the gathering storm: energizing and employing America for a brighter economic future”.[7] All these and other studies clearly demonstrate that within the U.S., there is a lack of talent entering the general science and technology workforce pipeline.

Recent reports also indicate that only 26% of U.S. high school graduates were considered to be qualified for entry into science or engineering programs in higher education. The numbers of students entering science and engineering as a percentage of students is a much smaller fraction than those in countries with which the U.S. has to compete, and actual numbers are small when set in a global context. A further issue is the reduction in numbers of trained science and engineering graduates entering and remaining in the U.S. and at least in some critical areas reductions in numbers of foreign students in U.S. programs. The ability to provide adequate numbers of educated and trained staff to meet U.S. energy industry needs can be expected to be a major and growing issue over the next decade.

There are various indicators that can be considered which highlight a wider U.S. science and technology crisis:

Patents - While patent applications in the U.S. more than doubled from 1989 to 2001, America's worldwide share of industrial patents, published scientific papers and Nobel prizes for the sciences is declining.

Math and Science College Graduates - While the number of overall college degrees has increased 14 percent between 1991-92 and 2001-02, the numbers have declined in some fields, such as engineering and mathematics.

Engineering Graduates - Engineering and engineering technologies graduates declined 3 percent between 1991-92 and 1996-97, and then posted a further 2 percent decline between 1996-97 and 2001-02. The number of mathematics degrees declined by 13 percent between 1991-92 and 1996-97 and posted a further 3 percent decline between 1996-97 and 2001-02. Mathematics degrees granted in 2001-02 had declined by 50% from the number granted in 1970-71. From 1997-98 to 2001-02, degrees in life sciences declined by 8 percent.

Out produced by China, Japan and India - According to the latest data, the U.S. is being out-produced nearly 5-to-1 per year in graduating engineers. While the U.S. produces approximately 80,000 engineers a year, China and Japan produce nearly 400,000. In China, three-quarters of all bachelor's degrees are in math, science, and engineering fields -- versus only about one-third in the U.S. Since 1990, the number of U.S. bachelor's degrees in engineering has declined by 8%, and mathematics degrees

have dropped by about 20%, according to the National Science Foundation's Science & Engineering Indicators most recent reports.[3,5]

Test Scores - The math skills of U.S. 15-year-olds rank 24th out of the 29 industrialized nations that belong to the Organization for Economic Co-operation & Development, according to a recent international test.

Shortage of Math & Science Teachers - Nearly 40% of U. S. high schools report difficulty filling math openings with qualified instructors, according to the American Association of Employment in Education.

Math & Science Teachers Not Trained in Math & Science - According to a report by the Council of Chief State School Officers in 2003, roughly 30 percent of math and science teachers do not hold a major, minor or regular certificate in their field.

Science Research Institutions – The U.S. in a recent survey is still reported to be the home for 38 of the top 50 global research entities, but it is unclear how long this position of dominance can be maintained.

The U.S. has for a long time supplemented its indigenous U.S. science and technology labor force by attracting foreign born and trained persons. Increasing global competition and slower entry for both foreign students and professionals is impacting this past shortcut to meeting U.S. trained workforce needs. For the nuclear industry the situation is further complicated by citizenship issues and access requirements for nuclear power and related facilities.

For the U.S. an indigenous next generation workforce is a critical element in ensuring the security of energy supply, particularly to support life extension and continuing operation of existing nuclear plants and the increasingly probable new build program. It is recognized with the 2005 Energy Policy Act[8] that it is critical for the U.S. to address energy supply issues, including workforce education and training.

Over recent years a series of studies and papers have reported and discussed the nuclear education and staffing challenge that is faced in maintaining and then rebuilding critical skills to meet the needs of the nuclear research and industry personnel pipeline.[1] For example, a report states that "Over the past decade the number of nuclear engineering programs in the U.S. has declined by half (from 80 to 40), the number of university research and training reactors by two-thirds (from 76 to 28), and total enrollments have dropped by almost 60% (from 3,440 to 1,520)".[9]

Several studies report B.S. and M.S. graduates in nuclear engineering numbers at about 200 per year.[10,11] Magwood cites a Nuclear Engineering Department Heads Organization (NEDHO) report[12] that states demand is for ~600 graduates annually and rising. Further, Magwood reported that total national undergraduate enrollment in nuclear engineering was just under 1,000 in 2001, down from a level of ~1,500 that persisted through the 1980s and until 1995.

Recent data regarding nuclear engineering degrees is available from the Oak Ridge Institute for Science and Education (ORISE).[13] This information shows:

B.S. level – 219 graduates in 2004, as compared with 222 in 1998 and a low of 120 in 2001.
M.S. level – 154 graduates in 2004, as compared with 160 in 1998 and a low of 130 in 2002.
Ph.D. level – 75 graduates in 2004, as compared with 98 in 1998 and a low of 67 in 2002.

In the last year total enrollment in nuclear engineering programs appears to be increasing and it was stated at a recent American Nuclear Society (ANS) meeting that there are now 1700 students enrolled which has returned the student population to the level of the late 1990's. However, it will be a few years before the upturn is reflected in numbers graduating at the B.S. level.

At the moment the demand for nuclear engineers still exceeds the supply. Enrollments are still very much lower than will be needed to support a nuclear energy resurgence. As with other areas of science the U.S. is only one part of a global picture, and in this case there is international concern regarding the supply of the nuclear educated and trained workforce.[14] The workforce needs range from skilled crafts and technicians (welders, instrumentation and mechanical) to highly qualified and certified professional engineers.[15] As new build opportunities are developed within the U.S. there are needs for specifically trained groups such as a new generation of startup engineers.[16]

There are also significant challenges in the areas of health physics, actinide chemistry, and related engineering and science disciplines needed to replace projected retirements in these communities and throughout the advanced energy research and production sectors.

## III. EXAMPLES OF INITIATIVES

Action is now being taken at several levels by a number of groups and organizations. National leadership has recognized the wider science and math competence

challenges to American competitiveness. President Bush stated in the State of the Union address (2006);

> "And to keep America competitive, one commitment is necessary above all: We must continue to lead the world in human talent and creativity. Our greatest advantage in the world has always been our educated, hard-working, ambitious people – and we are going to keep that edge. Tonight I announce the American Competitiveness Initiative, to encourage innovation throughout our economy, and to give our Nation's children a firm grounding in math and science."

We need to encourage children to take more math and science, and make sure those courses are rigorous enough to compete with other nations. ...Tonight I propose to train 70,000 high school teachers, to lead advanced-placement courses in math and science … bring 30,000 math and science professionals to teach in classrooms … and give early help to students who struggle with math, so they have a better chance at good, high-wage jobs..."

Other groups, such as the U.S. Chamber of Commerce have also established ambitious goals, for example:

- Seek support to double the number of science, technology, engineering and mathematics graduates by 2015
- Build public support for making science, technology, engineering and math improvement a national priority
- Motivate U.S. students and adults to study and enter these fields
- Upgrade K-12 math and science teaching to foster higher student achievement.
- Reform visa and immigration policies to enable the U.S. to attract and retain the best science, math and engineering students worldwide
- Increase funding for basic research, especially in the physical sciences and engineering

Similar goals are also being identified and addressed through numerous local and national initiatives by professional societies and institutes such as the American Association for the Advancement of Science (AAAS) and Institute of Electrical and Electronics Engineers (IEEE).

There remain major challenges, particularly for the energy industry, in improving public image, increasing available labor pools and in maintaining a stable labor supply.

Organizations sponsoring initiatives that are addressing parts of the workforce pipeline issue include:

- National Energy Foundation (K-12)
- U.S. Department of Labor
- Center for Energy Workforce Development
- Center for Advanced Energy Studies

**III.A National Energy Foundation (NEF)**

The mission of the National Energy Foundation is to provide teaching and learning opportunities which promote a better understanding of energy, natural resources, and the environment. Its mission is reflected in the resource materials produced and in the implementation of its programs.

The NEF is a unique 501 (c) 3 nonprofit educational organization dedicated to the development, dissemination, and implementation of supplementary educational materials, programs, and courses in schools. These resources for education relate primarily to energy, water, natural resources, science and math, technology, conservation, and the environment. All enrich and enhance teaching and learning. They recognize the importance and contribution of natural resources and energy to our economy, to our national security, the environment, and our quality of life.

The NEF is devoted to the implementation of a variety of innovative teacher training and student programs. The NEF Academy offers several university graduate credit, independent study courses developed for K-12 school teachers. More than two decades of expertise in carrying out effective educational partnerships has been supported by the education community, businesses, government agencies, and associations.

The NEF is continuing to expand its role as the premier provider of educational resources dealing with energy, natural resources, and the environment by expanding its products, training, and services, creating and implementing new and innovative educational resources, by becoming extensively involved in the use of the Internet, and transforming printed educational materials to new mediums, thereby making it possible to significantly expand its impact throughout the nation.

### III.B U.S. Department of Labor

Since 2003, U.S. Secretary of Labor Elaine L. Chao has announced ten investments totaling nearly $27 million to address the workforce needs of the energy industry. The U.S. Department of Labor's Employment and Training Administration (ETA) has sought to understand and implement industry-identified strategies to confront critical workforce challenges. Through multiple forums, the ETA has listened to employers, industry associations, labor-management organizations, and others in the energy industry regarding efforts to identify challenges and implement effective workforce strategies. The ETA has worked with the energy industry to identify its hiring, training, and retention challenges in its sectors ranging from oil and gas to utilities and mining.

The challenges faced are far too complex for one institution or industry sector to solve alone. Investments in the High Growth Job Training Initiative for the energy industry support comprehensive partnerships among employers, the public workforce system, and other entities that have developed innovative approaches to meet workforce needs while effectively helping workers find good jobs with good wages and promising career pathways. Solutions being developed are based on the energy industry's priorities that address the following issues:

- Employers expect that up to half of their current workers will retire over the next five to ten years.
- Stereotyping of energy careers as unstable, dirty, and low-skilled causes qualified workers, especially youth, to be unaware of the many highly skilled, well-paying career opportunities.
- Many training programs were scaled back or closed due to a downturn in the industry in the late 1980s and early 1990s.
- Programs have not ramped up at the same rate that the industry's need has rebounded.
- Employers in all sectors of the industry need workers who are more proficient in math, science, and, especially, technology than workers in the past.
- Creative solutions are necessary to help experienced workers who will be retiring transfer their knowledge and skills to their replacements and to help new workers gain necessary skills as quickly as possible.

Few industry-defined, portable credentials have been developed in the energy industry. Additionally, some energy occupations lack unambiguous career ladders necessary for changing a perception that working in the industry is a viable career choice. To address these challenges energy industry grants are being awarded to provide genuine solutions, leadership, and models for partnerships that can be replicated in different parts of the country.

### III.C Center for Energy Workforce Development (CEWD)

The Center for Energy Workforce Development is a non-profit consortium of electric, natural gas and nuclear utilities and their associations, the Edison Electric Institute, American Gas Association, and Nuclear Energy Institute that was formed in March, 2006. The CEWD was formed to help utilities work together to develop solutions to the coming workforce shortage in the utility industry. It is the first partnership between utilities, their associations, contractors and unions to focus on the need to build a skilled workforce pipeline that will meet future industry needs.

The CEWD is also teaming with secondary and post secondary educational institutions and the workforce system to create workable solutions to address the need for a qualified, diverse workforce.

The CEWD has also established a partnership with the International Brotherhood of Electrical Workers. The large contingent of the utility workforce that is represented by the union and the apprenticeship programs that train them are a critical element is the industry solution to workforce issues. In addition, CEWD has partnerships with the Association for Career and Technical Educational, the Energy Providers Coalition for Education, The American Association of Community Colleges, and the National Association of Workforce Boards.

### III.D Center for Advanced Energy Studies

Part of the U.S. energy strategy includes the formation of the new Idaho National Laboratory (INL). The INL, which has a key nuclear energy mission was officially established February 1, 2005. The Battelle Energy Alliance (BEA), in responding to the request for proposal[17] for the new INL, developed a partnership with the State of Idaho, an Idaho University Consortium (IUC), a National University Consortium (NUC) and various industrial organizations to establish a joint institute, the Center for Advanced Energy Studies (CAES).

CAES is defined by the U.S. Department of Energy[17] as being:

> "… an independent entity, in which the INL and Idaho, regional, and other universities cooperate to conduct on-site research, classroom

instruction, technical conferences, and other events for a world-class academic and research institution".

The Secretary of Energy, Samuel Bodman, formally inaugurated the programmatic activities for CAES on June 1, 2005. The need for CAES, in association with the INL and its academic partners, to address key energy challenge issues is evident given the current U.S. and global energy situation, U.S. science and engineering educational challenges, and the combination of current energy industry workforce demographics and future workforce projections.

This institute will be a partnership which integrates government, industry and university resources and it will engage a wide network of other national and international organizations.

## IV. SUMMARY/CONCLUSIONS

In the past two years there has been a growing recognition of the workforce challenges that are facing the U.S., particularly within the energy sector. People in leadership positions are recognizing the significance issues of workforce demographics that will be faced over the next decade, the inadequacy of U.S. levels of competence in science and mathematics and the need to attract a new generation of staff, at all levels from crafts and technicians to professional engineers, into the energy and particular the electricity/nuclear energy sector. These needs range from those in the fundamental research community through to plant operations and industry needed to support new build for plants within the U.S.

There are a growing range of initiatives being developed which address workforce challenges. Federal and state/regional agencies and industry organizations are increasingly teaming in entities such as the Center for Energy Workforce Development, the National Energy Foundation, and the Center for Advanced Energy Studies.

Based on our knowledge of the comprehensive workforce picture, several needs stand out requiring immediate attention of the aforementioned organizations as they pursue their mandate to improve the availability of personnel to staff the nation's energy infrastructure. These include:

- More robust data gathering and analysis across the energy sector concerning the status of specific disciplines to include the demographics of the current population. Good information is being gathered by the Nuclear Energy Institute for the nuclear segment; however, the energy sector as a whole is not well covered. The new Center for Energy Workforce Development will hopefully lead in resolving this need.
- The "pipeline" between K-12, vocational-technical, community colleges and colleges/universities needs to be more of a continuum such that students can continue to advance in educational pursuits.
- Direct industry involvement with educational institutions, while improving on some fronts, needs further emphasis to ensure that learning institutions are producing graduates that meet the current and emerging needs of the sector.
- While energy sector workforce issues are reaching critical proportions, the need for qualified teachers and college professors must also receive equal attention.

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